News from JR

Pedro Jimenez-Delgado
(with Ewald Reya)

Standard Model Benchmarks at High-Energy Hadron Colliders

Universität Zürich UZH

technische universität dortmund

News from JR

The dynamical approach to parton distributions

Typical dynamical vs “standard” results

Predictions for Hadron Colliders

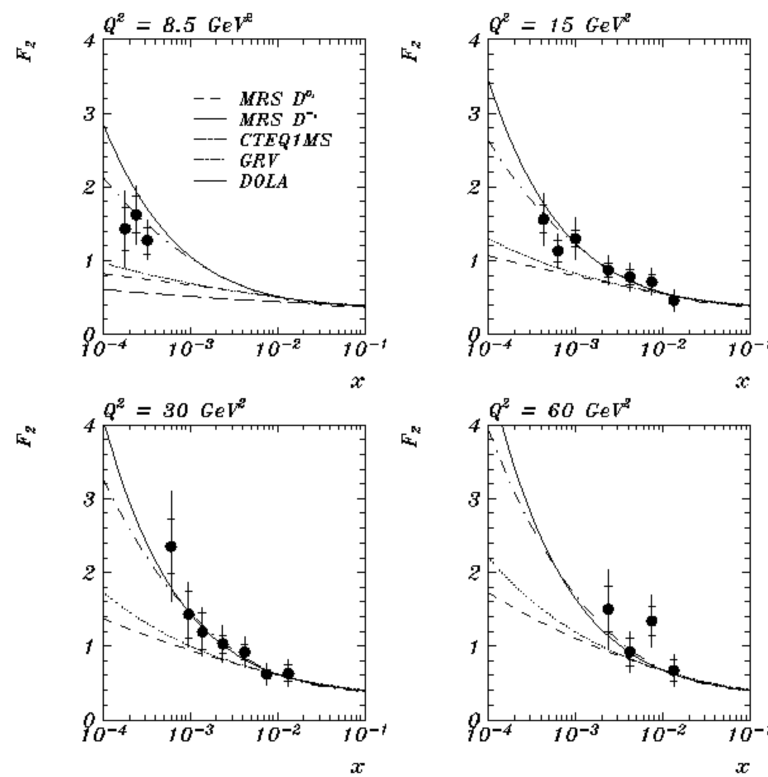
Current and future investigations

Brief history of the dynamical PDFs

Dynamical assumption [Altarelli, Cabibbo, Maiani, Petronzio 74], [Parisi, Petronzio 76], [Novikov 76], [Glück, Reya 77] in connexion with the *constituent quark model*: only valence quarks

First dynamical determination of parton distributions [Glück, Reya 77]

Used in the 80's: e.g. for the discovery of W and Z bosons (SPS, CERN)



Extended to include **light sea** [Glück, Reya, Vogt 90] and **gluon** [Glück, Reya, Vogt 92] **valence-like input**
$\longrightarrow$ **steep gluon and sea at small-x!!**

Confirmed by first HERA $F_2(x, Q^2)$ data [H1, ZEUS 93]

GRV95 and GRV98 contributed greatly in the 90's and beginning of the 00's

Improved generation (GJR08, JR09):
new data, NNLO, error analysis, FFNS+VFNS ...

Global QCD analysis and data

Determination of non-perturbative information: **input distributions** $f(x, Q_0^2)$

Experimental information + **pQCD** theory (RGE + cross sections) + **parametrizations** (Least Squares and Hessian methods)

Light quarks + gluon: $f = u, d, s, \bar{u}, \bar{d}, \bar{s}$ and g (no need for heavy-quark PDFs)

FFNS for DIS and VFNS for hadron colliders (no need for GMVFNS's)

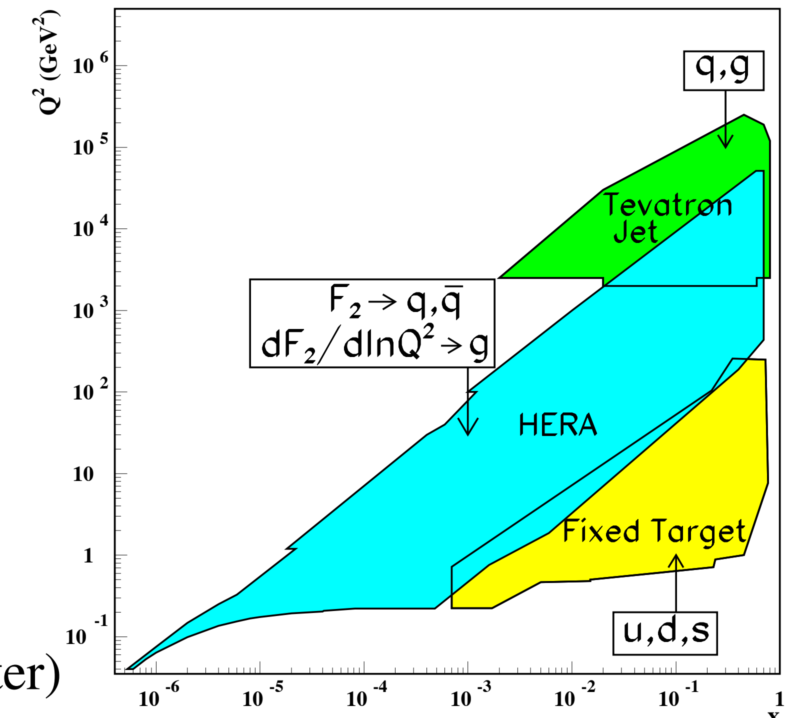
Selected data in (G)JR *global* analyses:

DIS structure functions (most relevant)

Drell-Yan (pp + pn) muon pair production instrumental for $\bar{d} \neq \bar{u}$

Jets from Tevatron (up to NLO)

Not very sensitive to strange PDFs
$\Rightarrow$ input assumptions $s = \bar{s}$ ($= 0$, discussed later)



[PDG Review]

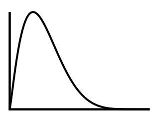
Other data (e.g. ν DIS, W asym., DIS jets, ...) provide only *complementary* information

The dynamical parametrization

Typical polynomial parametrization: $xf(x, Q_0^2) = N x^{\mathbf{a}} (1-x)^b (1 + A\sqrt{x} + Bx)$

Since we are free to (and have to) select an input scale for the RGE:

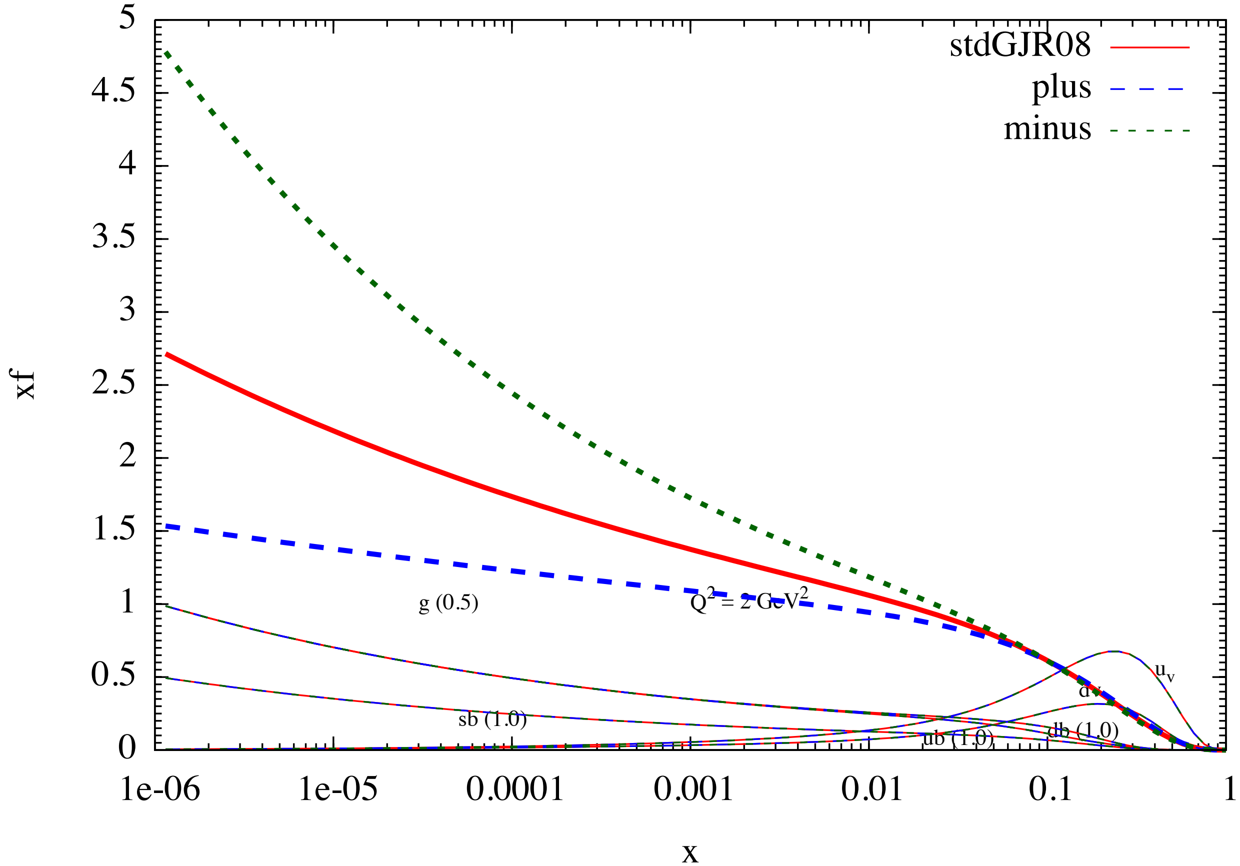
At low-enough Q^2 only "valence" partons would be "resolved"
$\Rightarrow$ *structure at higher Q^2 appears radiatively (i.e. due to QCD dynamics)*

DYNAMICAL:	**"STANDARD":**
$Q_0^2 < 1$ GeV^2 optimally **determined**	$Q_0^2 = 2$ GeV^2 arbitrarily **fixed**
$\mathbf{a} > 0$ *"valence-like"* 	*Fine tunning* to particular data ($g < 0!$)
QCD *"predictions"* for small-x	**Extrapolations** to "unmeasured" regions
More predictive, **less uncertainties**	More adaptable, *marginally* smaller χ^2

There are **NO EXTRA CONSTRAINTS** *involved in the dynamical approach!*

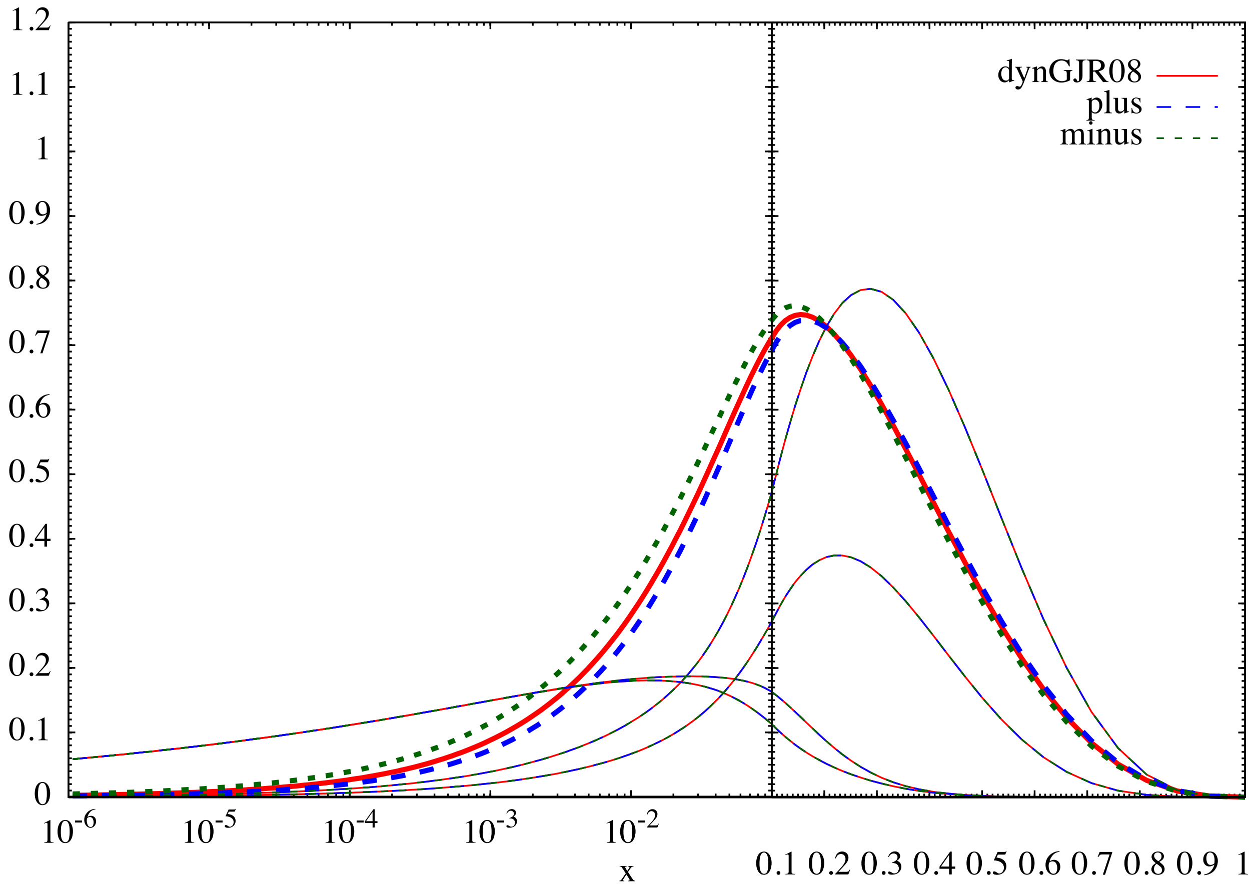
Physical motivation for the **CC of the RGE $\neq$ NP structure** of the nucleon

The dynamical parametrization: an illustration



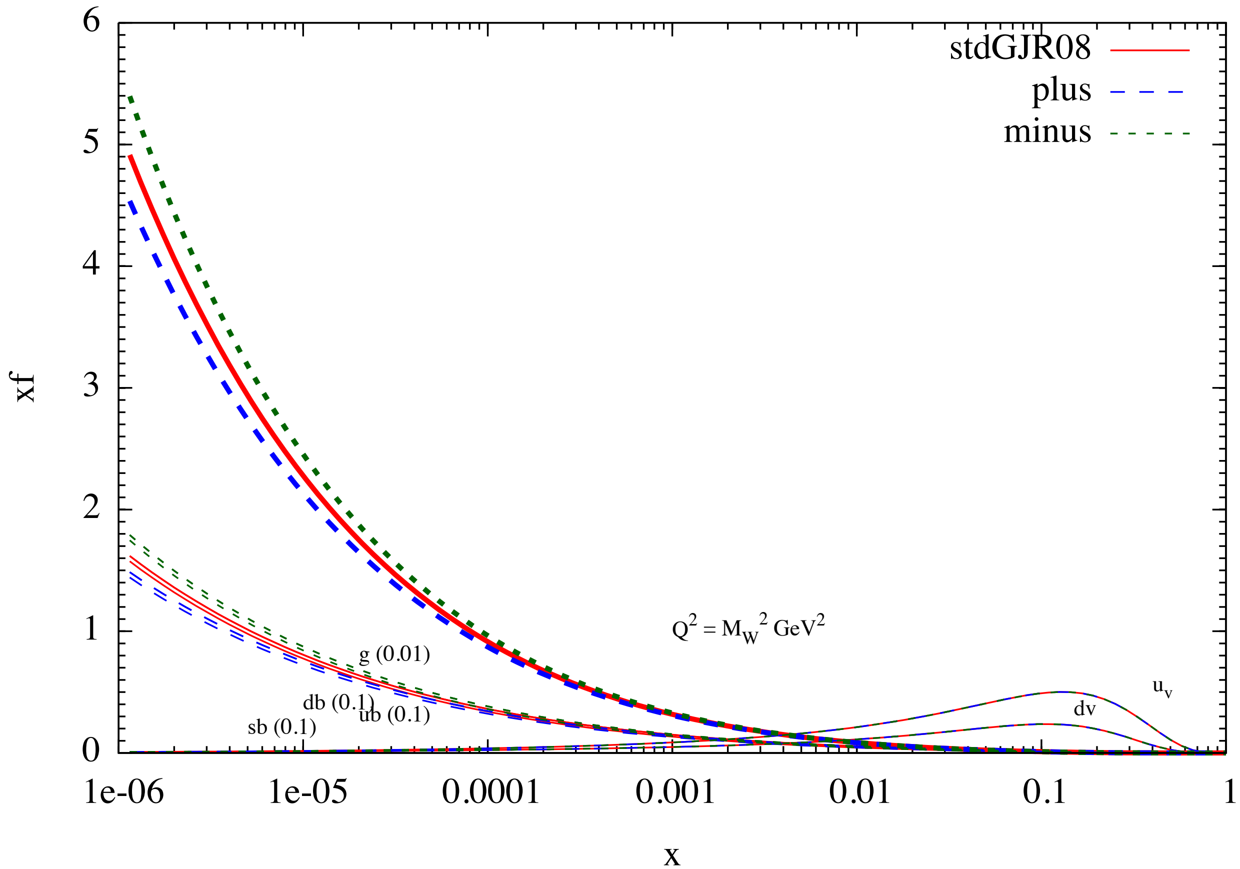
“standard” GJR08 NLO input with $a_g \pm 0.05$ at $Q_0^2 = 2$ GeV^2

The dynamical parametrization: an illustration



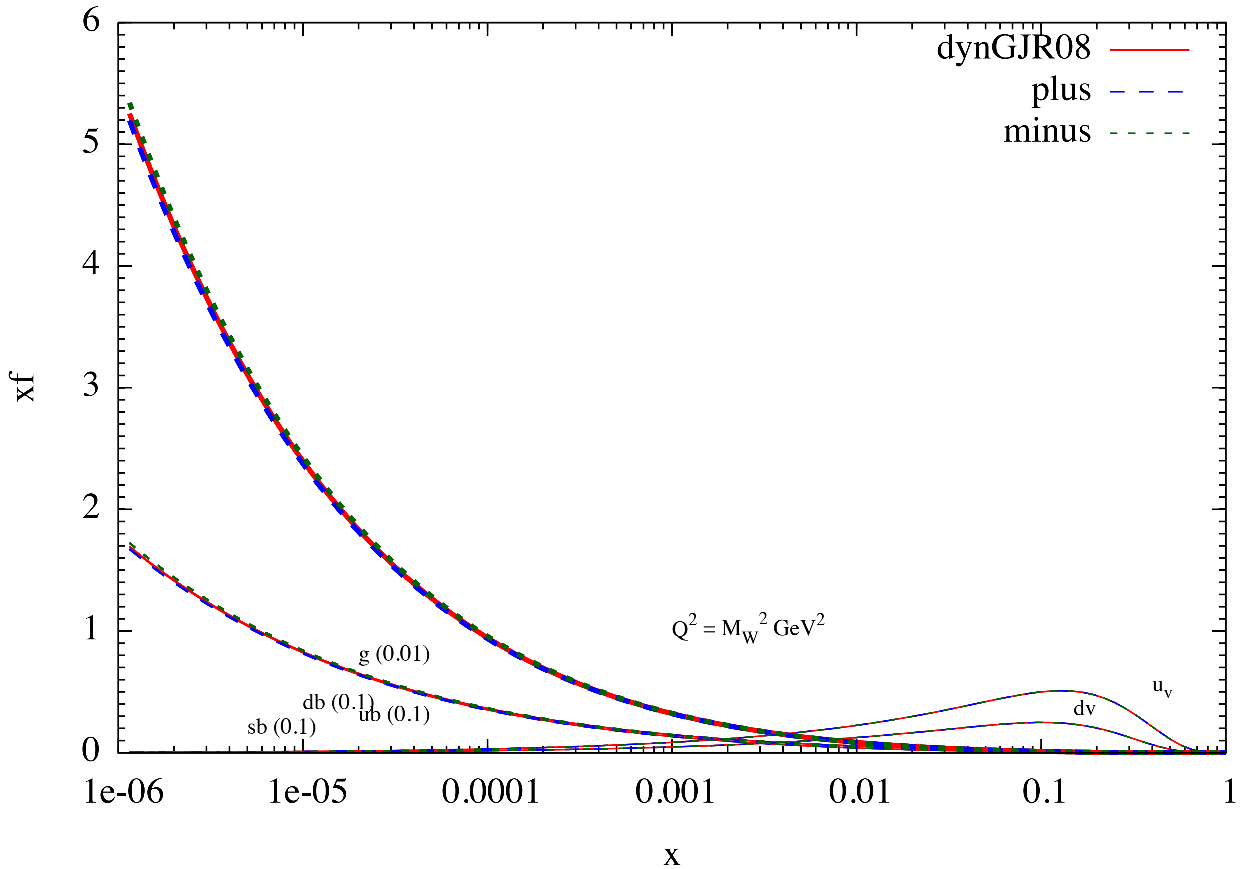
dynamical GJR08 NLO input with $a_g \pm 0.05$ at $Q_0^2 = 0.5\ \text{GeV}^2$

The dynamical parametrization: an illustration



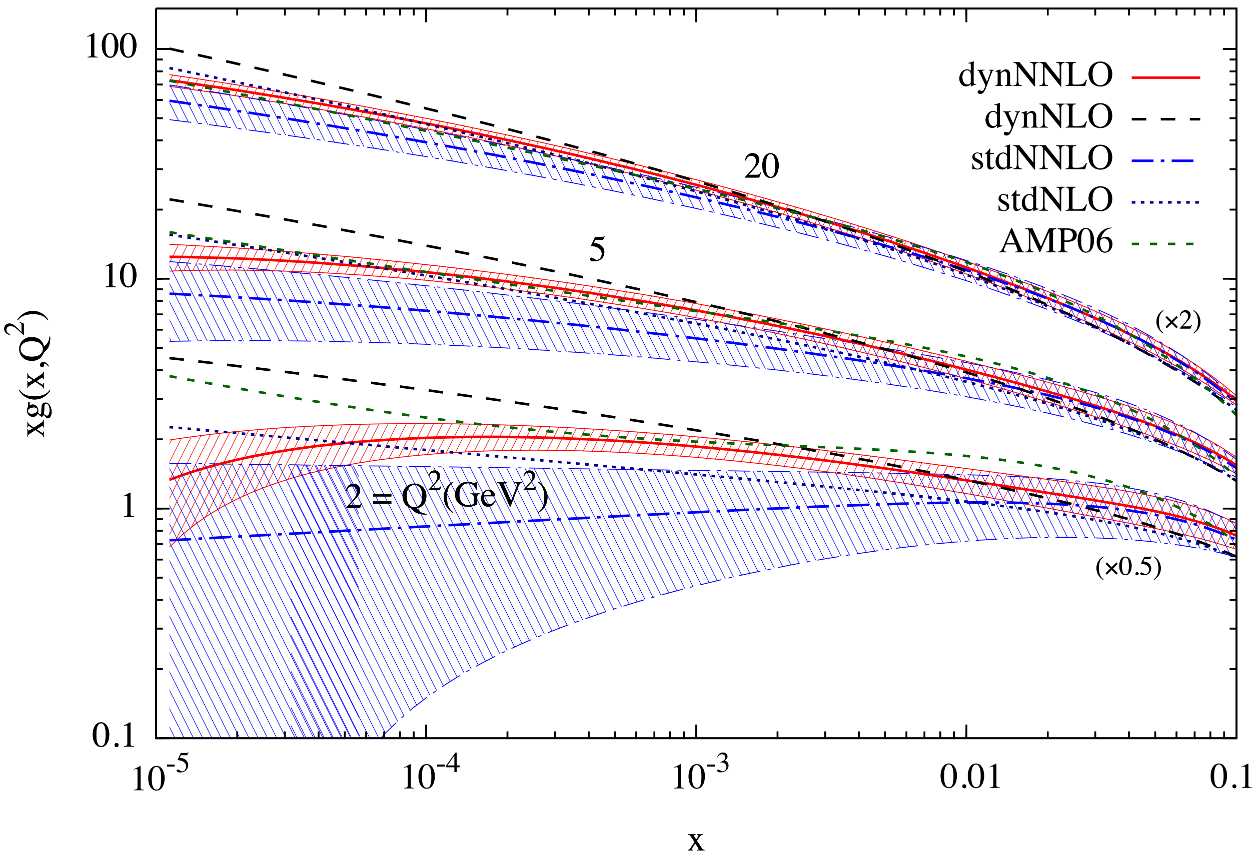
... resulting "standard" distributions at $Q^2 = M_W^2$

The dynamical parametrization: an illustration



... resulting dynamical distributions at $Q^2 = M_W^2$, more "constrained"

Typical dynamical vs "standard" results: gluons



Results more constrained as Q^2 increase due to pQCD evolution

larger "evolution distance"+ *valence-like* input

$\Longrightarrow$ **less uncertainties** and **steeper gluons** (correspondingly smaller α_s)

Fine tunning marginal (e.g. for DIS at NNLO $\chi^2_{dyn} = 0.90$ comparable to $\chi^2_{std} = 0.87$)

Typical dynamical vs "standard" results: α_s

$\alpha_s(\mu^2)$ and HQ masses are *parameters* which *depend on the theoretical input* (order, scheme, scales, etc.)

It is **desirable** that their values come out of the global PDF fits

We determine $\alpha_s(M_Z)$ **together** together with the distributions:

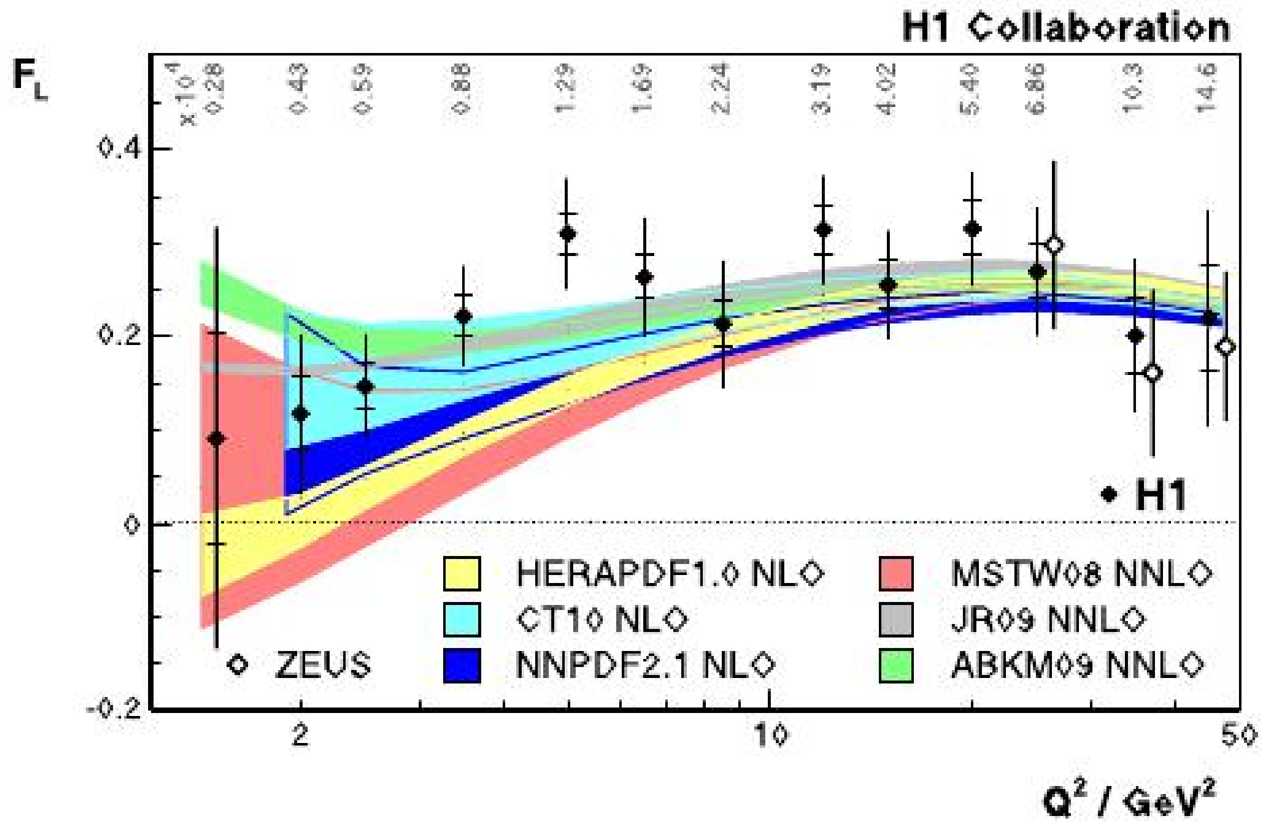
	dynamical	**"standard"**
NNLO	0.1124 ± 0.0020	0.1158 ± 0.0035
NLO	0.1145 ± 0.0018	0.1178 ± 0.0021
LO	0.1263 ± 0.0015	0.1339 ± 0.0030

Dynamical approach reduces the uncertainty! (in particular at NNLO)

Dynamical results are smaller: larger "evolution distance" ($Q_0^2 < 1\,\mathrm{GeV}^2$)

Differences should be interpreted as **uncertainties** (*not* be "removed" by convention!)

Typical dynamical vs “standard” results: F_L



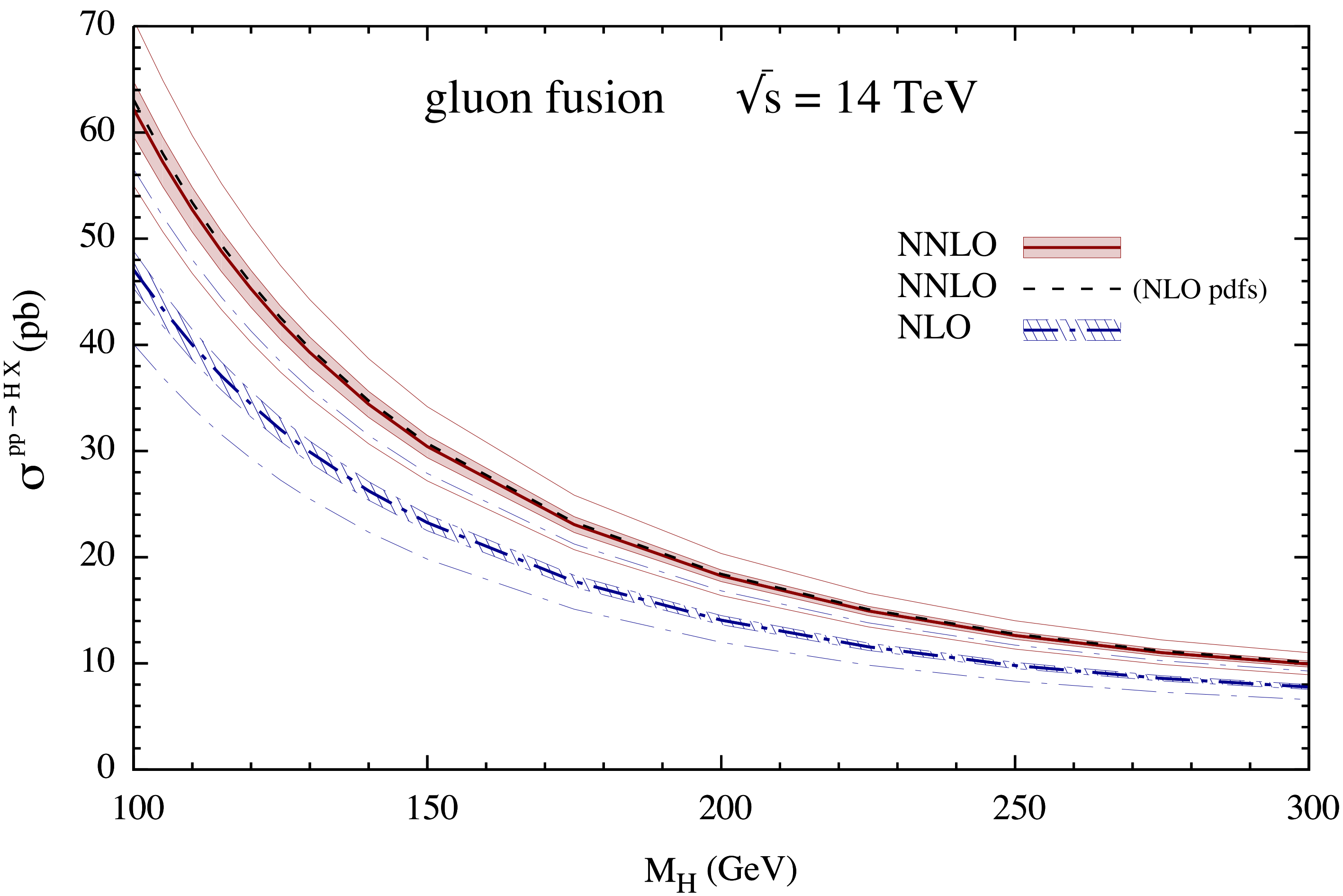
[H1 2011]

Positive and in complete **agreement** with measurements

Greater precision achieved within the dynamical framework

Other results less precise and even **turning negative** at the lower Q^2 values

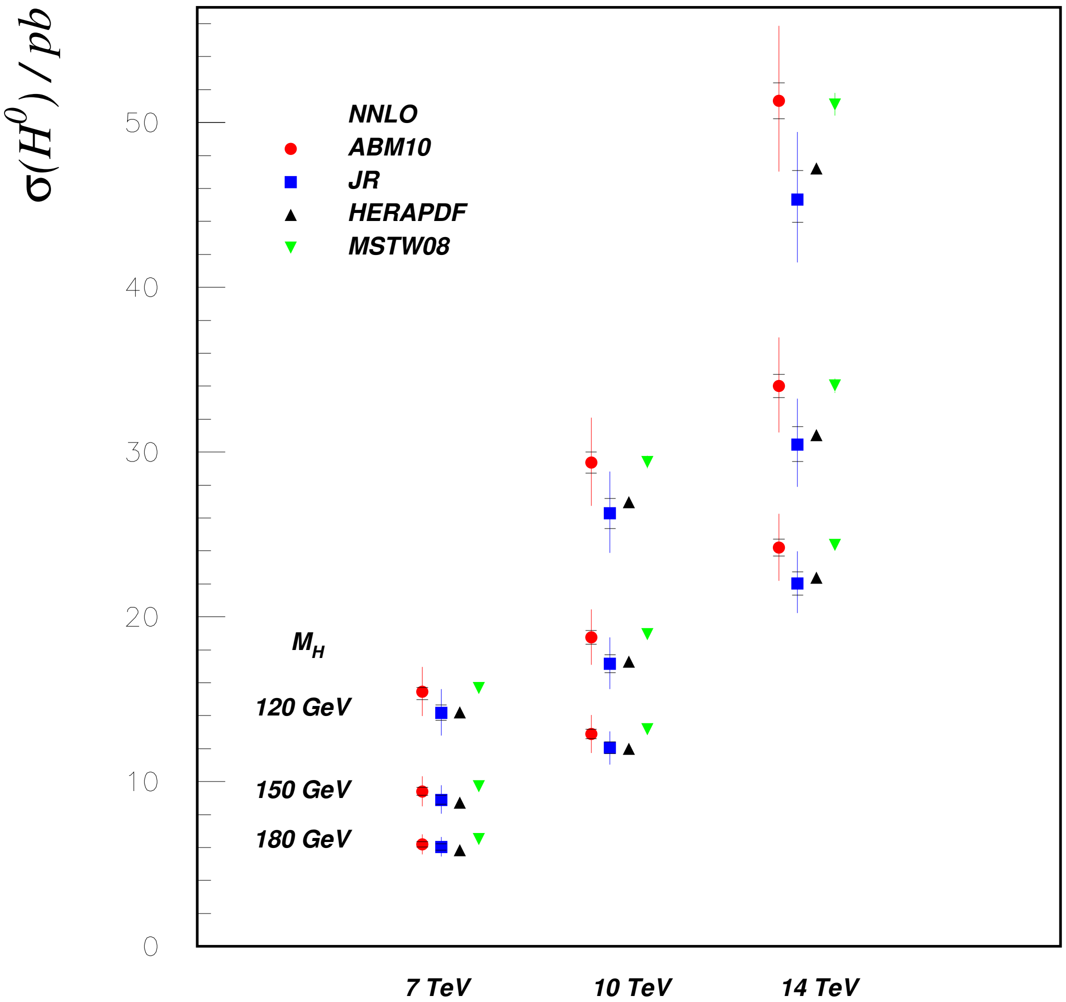
Higgs boson production at LHC



NNLO rather (20%) larger than NLO but *total* uncertainty bands overlap

Our total errors at NNLO less than 10%. Not *very* dependent on PDF details

NNLO benchmarks for Higgs production



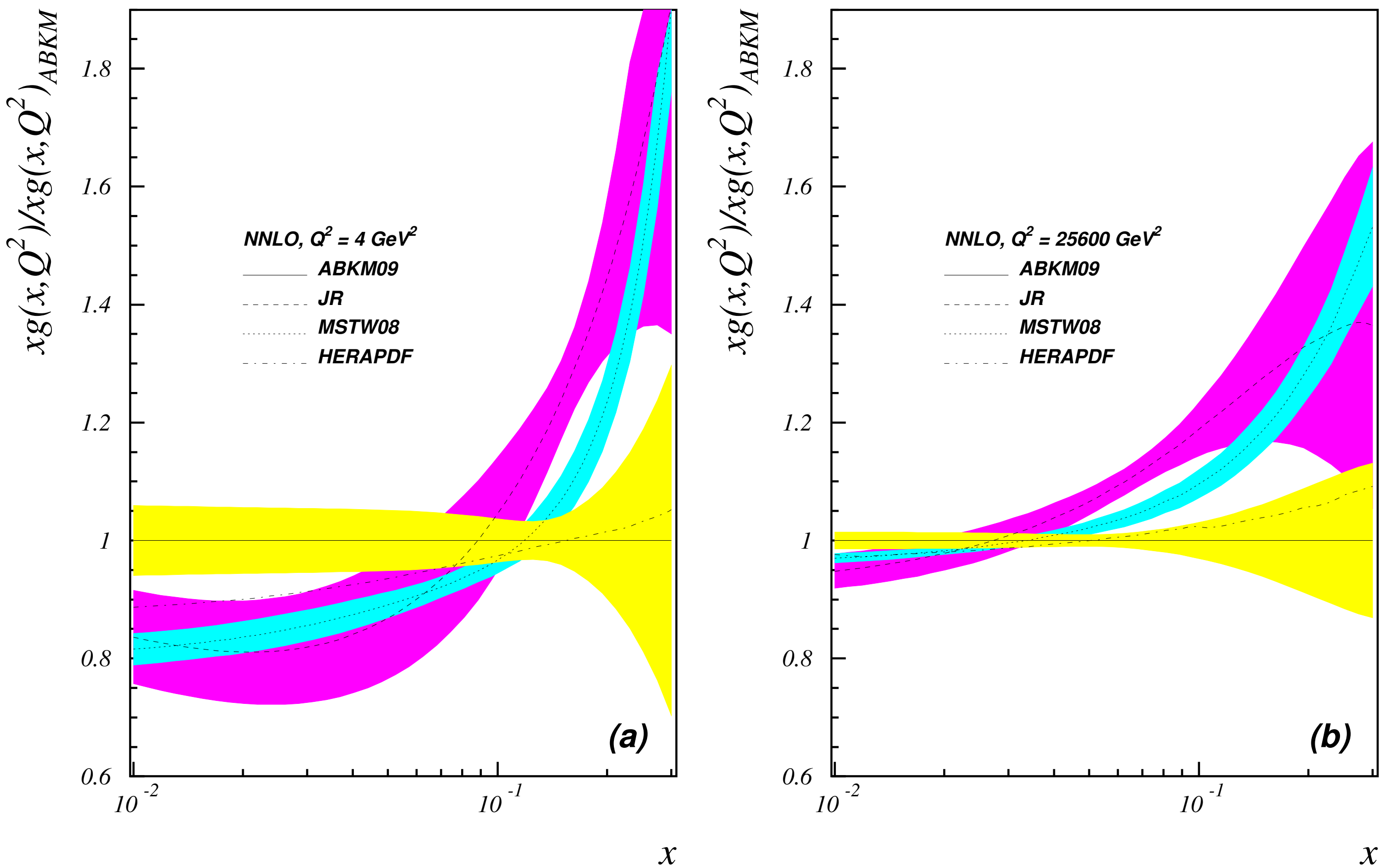
Considering the different NNLO results $\approx 10-20\%$ **accuracy at LHC**

Differences due to $\alpha_s(M_Z^2)$ and gluon distributions, **largely understood**

Comparison of parton luminosities

Dominant gluon fusion $\propto \alpha_s^2$, and **quadratic in the gluon** (anticorrelated)

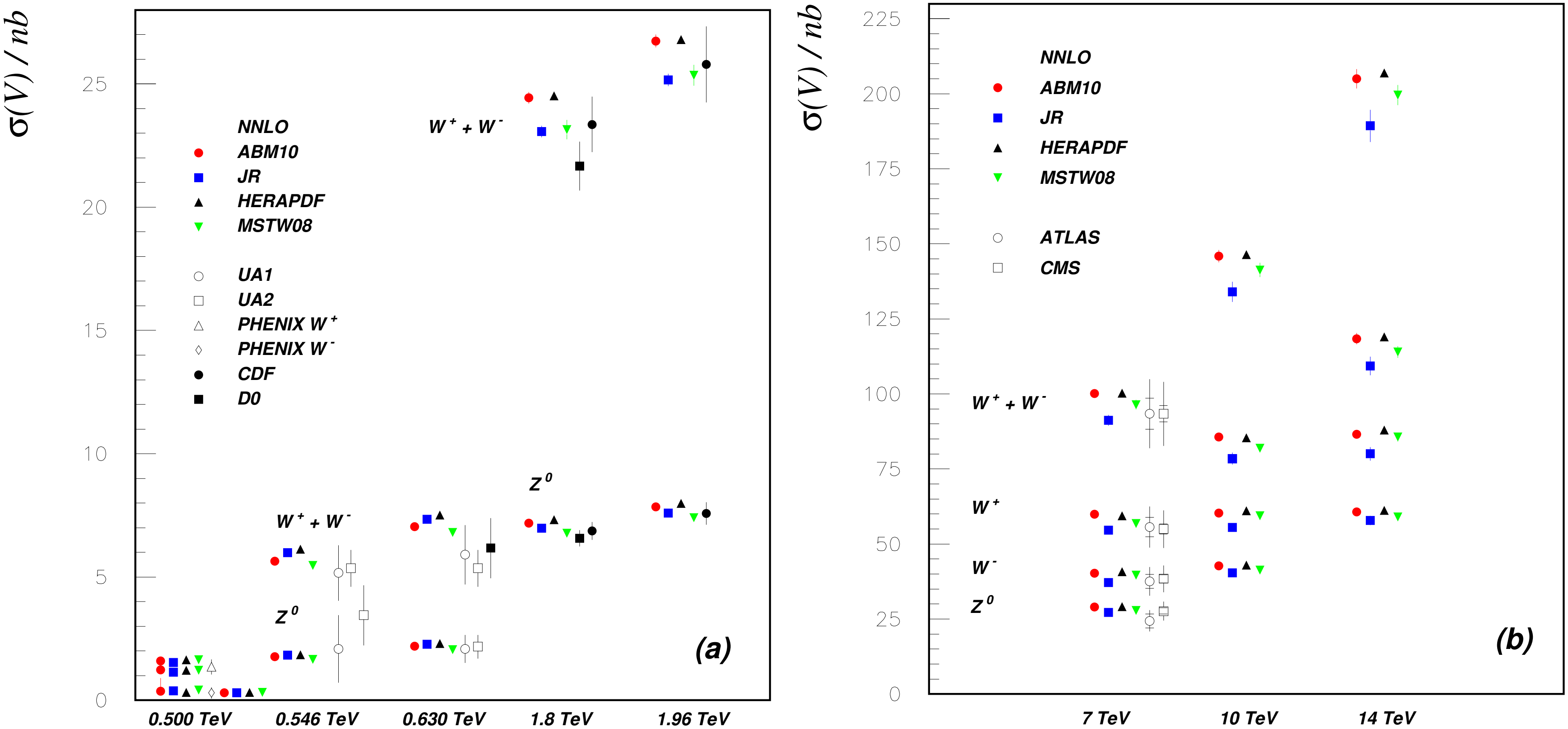
Obtained $\alpha_s(M_Z^2)$ about 4(3)% smaller for JR(ABKM09) than for MSTW08



Differences of about 5% for $< x >= \sqrt{x_1 x_2} = \frac{M_H}{\sqrt{S}} \approx 10^{-2}$ relevant for LHC

(For Tevatron 10-20% at $< x > \approx 10^{-1}$)

NNLO production rates for W and Z



Results from different groups **agree within experimental** uncertainty

Considering results from different groups **accuracy better than** $\approx 10\%$ at LHC

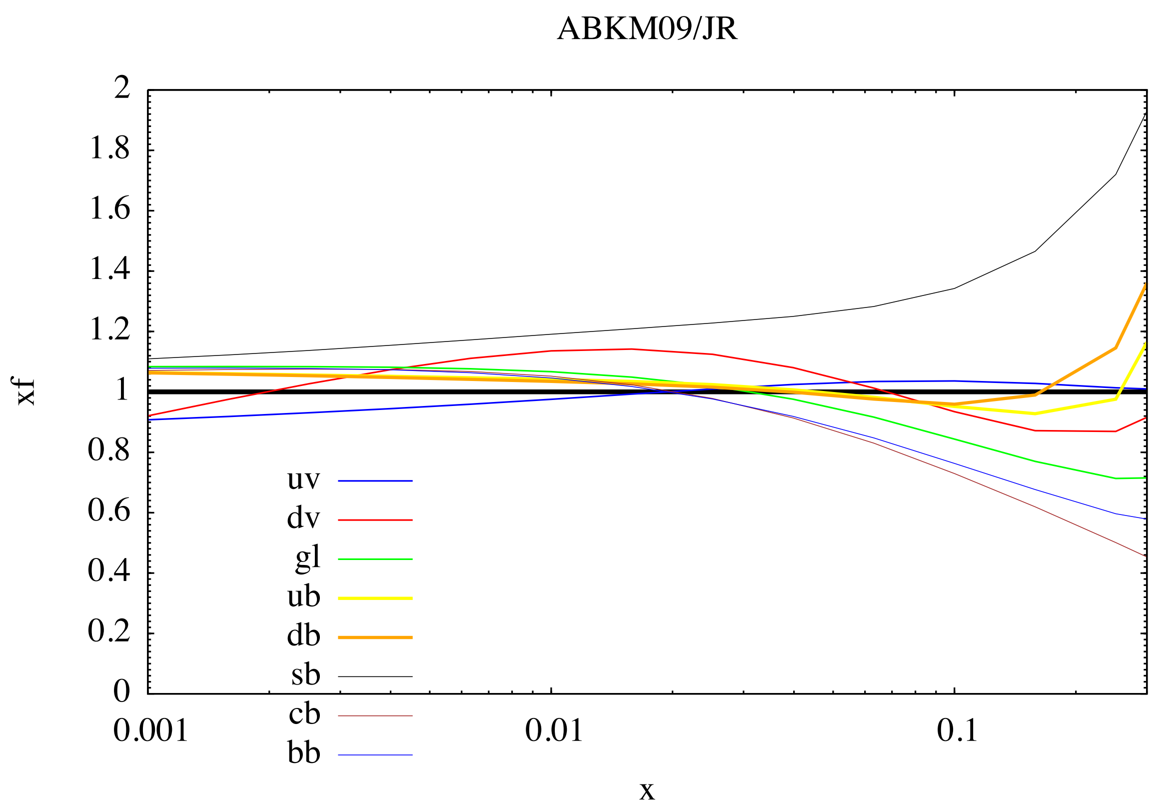
First investigations point to *differences in light-sea* (and valence) distributions

Current investigations: strange sea

Dynamical strange sea generated from $s(x,Q_0^2)+\bar{s}(x,Q_0^2)=0$

Ansatz in *agreement* with current dimuon production data [PJD 2010]

However other groups have larger strange distributions. Example at $Q^2=M_W^2$

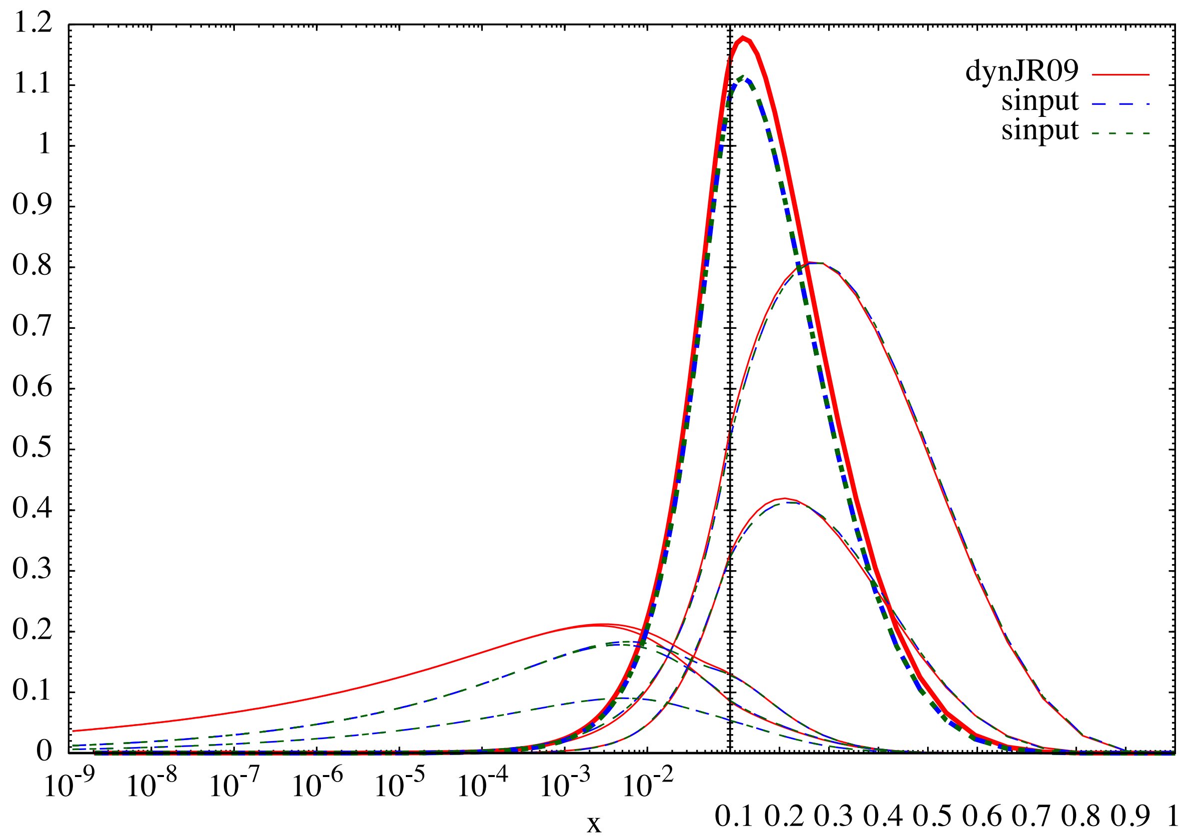


Does this (partially) explains the differences in W/Z production rates?

Current investigations: strange sea

From dimuon production data $\bar{s}(x,Q_0^2) \simeq 0.1[\bar{u}(x,Q_0^2)+\bar{d}(x,Q_0^2)]$

"sinput" variant: $\bar{s}(x,Q_0^2) = 0.25[\bar{u}(x,Q_0^2)+\bar{d}(x,Q_0^2)]$ (as in our "standard" fits)



Larger input strange sea "compensated" by the other sea distributions

In fact the vector boson production **rates remain practically unaffected!**

Current investigations: NMC data

The ABM group has reported **changes in the gluon** and a shift of $\Delta\alpha_s(M_Z) = 0.0035$ due to different treatments of NMC data (F_2 **vs** σ)

Similar (preliminary) studies within our ("standard" NNLO) framework results in **only** $\Delta\alpha_s(M_Z) = 0.0006$ (in the same direction)

Including **higher-twist** (as ABM) we find slight changes in the gluon distribution and a shift of $\Delta\alpha_s(M_Z) = 0.0019$ with respect to the stdJR09 result

The sensitivity of the analyses to the treatment of NMC data is *reduced by kinematical cuts* (and further by the treatment of correlated errors [S. Alekhin])

Preliminary studies using (inconsistently) *jet data* also at NNLO indicate that they have *little influence*

Within the **dynamical** framework the **effects** are even **smaller** due to the more "constrained" (predictive) parametrization

Future investigations and/or improvements

Switch to combined (H1 + ZEUS) results with increased precision

Include also charged current DIS from HERA? (complementary)

Not W-asymmetries from Tevatron (subject to experimental debate)

NuTeV dimuon data instrumental for strangeness: only at NLO? $s \neq \bar{s}$ input?

Some LEP constraints on $\alpha_s(M_Z)$? (preliminarily seem to have only a small effect)

Switch to "running" strong coupling? [AM 2010]

Revise heavy-quark masses?

Nuclear corrections?

Higher-twist and kinematical cuts?

Experimental correlations?

Alternative parametrizations?

... let us know your suggestions!

Summary and conclusions

The dynamical "model" is a *well-established* approach to parton distributions:

- supported by *all* current data
- greater **predictive power** in the small-x region

(more constrained without additional constraints!)

Last (G)JR generation of dynamical PDFs: NNLO, FFNS + VFNS, errors, ...

Different NNLO predictions result in **10-20%** (**less than 10%**) accuracy for **Higgs** (**vector boson**) production at LHC

Preliminary studies show that the **dynamical predictions are stable** under a range of variations in the fits

More studies/improvements to come